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SEXTANT

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SEXTANT WITH ATTACHED SPIRIT-LEVEL HORIZON.

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It very frequently happens that the traveler and the navigator are placed in situations where it is in the highest degree desirable to determine their geographical positions, or to measure the elevation of some mountain by an altitude or depression, and yet the means at their command may be inefficient. At sea, the sextant is the best available instrument for measuring angles of elevation or azimuth, but for the former purpose it can be used only when the object and sea horizon are both visible. Sometimes, however, when it is very desirable to measure an altitude, the sun is so low that the bright and dazzling reflection from the surface of the water obscures the horizon; or the horizon is hidden by a low fog whilst the sun is visible through it.

On shore, the traveler, whose outfit of astronomical instruments is limited to a pocket chronometer, sextant, and artificial horizon, finds constantly annoying occasions when his means fail him in important determinations. The sun may be too high for observing double reflections with the ordinary sextant; the sun or a mountain may be too low to admit of available reflection in the artificial horizon; and in particular these means positively fail him when, from any elevated point, he wishes to measure the depression of some object, as of the sea horizon, by which to determine his elevation or distance, knowing one of them, or, knowing the distance of another and lower mountain, to determine the difference of elevation.

We have encountered all these difficulties, and also the less frequent one of falling in with a reef at night with the stars visible but the sea horizon totally obscured in darkness. This occurrence first directed our attention to the subject of adjusting an artificial horizon to the sextant about twelve years since, but we failed to solve the problem. Three years since, when daily using the hand-level generally known to the trade as Locke's level, we saw the means at our hand ready for application, and fitted it to a Gambey sextant.

Plate IV. shows this level in detail. Fig. 1 gives the general appearance of the sextant and the attached level; Fig. 2 is a transverse section through the bubble, cross wire, and reflector; Fig. 3 is a longitudinal section through the bubble, reflector, and double convex lens. The tube B carrying the spirit-level is closed at each end with

plane glasses G G; the half of the tube lengthwise and on the side nearer the face of the sextant is unoccupied from end to end to permit vision directly through the plane glasses to any object or reflected object, whilst the other half carries the reflector R, having its reflecting surface towards the observer and placed at an angle of 45° with the axis of the tube, which also carries the half or segment of a double convex lens L secured in the inner tube T, which is capable of adjustment for difference of vision in different observers. Towards the object end of the tube B, over an opening above the reflector, is secured a small spirit-level S, with its axis parallel to the tube, and having, immediately beneath the tube, an adjustable frame F carrying a fine wire W at right angles to the axis of the tube and parallel to the horizontal plane. The images of the bubble of the spirit-level and of the cross wire are reflected through the lens to the eye of the observer. Other equivalent means may be employed for the above purposes, such as a prism for the reflector, &c.

For observations on land, where the instrument may be held with more steadiness than at sea, or even secured to a fixed object, a small telescope, such as the weakest power usually furnished with the sextant, may be fitted to the eye end of the tube, and thereby afford better results.

We have affixed the level to the sextant by having a tube C, about one inch in length, with a milled head M and exterior screw collar to screw into the telescope holder H of the instrument, and then sliding the tube B into it. This permits the use of the usual telescopes by removing the tube C.

The adjustment of this level is made either by changing the angle of the reflector, or moving the frame carrying the cross wire, or by elevating one end of the level itself; and consists in making the image of the cross-wire bisect the image of the bubble when a distant object in the same horizontal plane and seen through the unoccupied half of the tube appears on a level with the image of the cross-wire. This adjustment is readily effected on land, may be made by means of the level itself, and is not easily deranged. Should it, however, become necessary to adjust the level at sea, the image of the cross-wire, when it bisects the image of the bubble, is made to appear on the same line with the visible horizon; and the correction for the dip of the horizon at the given height of the observer's eye is applied to all observed altitudes and depressions.

The index error may be determined when the level is adjusted on land and used as a constant quantity for a not very extended series of observations, or it may be determined at sea whenever the horizon is visible, by observing the depression of the horizon and taking the difference or sum of the observed result and the computed dip for the index error.

The operation of making an observation for the altitude or depression of any object at sea or on land is as follows: Secure the level in its proper place on the instrument and hold the sextant in the usual manner, with the plane of its face in the vertical plane passing through

the object and the observer. Looking through the tube, move the vernier arm until the image of the object is seen through the unoccupied half of the tube, and bring that image into the same horizontal line with the image of the cross-wire at the time it bisects the image of the bubble, and if necessary note the time by chronometer. If the sextant and the level are in adjustment, the reading on the arc indicated by the vernier is the observed altitude or depression of the object.

At night, observations may be made by illuminating with a lamp or by chemical means. We have observed the altitude of the moon without any artificial light. Prof. Frazer suggests, as a chemical means of illumination, a small tube, containing phosphorus in oil, capable of being placed over the level at pleasure, and a small quantity of air admitted when the instrument is required for night observations. The length of the bubble of the unground level we experimented with was two-tenths of an inch, but should be shorter. The level had a radius of curvature of fifty-six inches, but for sea observations it may be smaller for bad weather and until practice be acquired.

The following results from observations for latitude are given as exhibiting what was done at the second and third trials with the instrument. It is believed that, with practice and a level adapted for the duty, much better results can be obtained, especially in the hands of a more experienced observer with the sextant.

Latitude from circummeridian altitudes of the sun with sextant and spirit-level horizon. Observations of November 11*th commenced* 5 *min.* 48 *sec. before apparent noon, and ended* 11 *min.* 18 *sec. after noon. November* 12*th commenced* 7 *min.* 23 *sec. before, and ended* 5 *min.* 55 *sec. after apparent noon.*

	November 11, 1865.		November 12, 1865.	
	$\overline{\odot}$	$\underline{\odot}$	$\overline{\odot}$	$\underline{\odot}$
	39° 59′ 18″	39° 57′ 14″	39° 60′ 12″	39° 54′ 19″
	55′ 55″	57′ 36″	59′ 28″	56′ 37″
	57′ 05″	57′ 18″	57′ 51″	56′ 31″
	56′ 52″	58′ 41″	57′ 39″	58′ 13″
	57′ 55″	59′ 43″	56′ 01″	57′ 51″
	55′ 52″	61′ 27″	56′ 59″	58′ 29″
	58′ 41″	. . . . .	58′ 54″	59′ 01″
Means,	39° 57′ 23″	39° 58′ 38″	39° 58′ 09″	39° 57′ 17″

These reductions have been unnecessarily made to seconds of arc that the actual working of the instrument may be seen; the probable error of one observation deduced from these series is one minute of arc, and the probable error of the mean of all the observations is thirty-five seconds of arc. This, of course, excludes whatever constant errors may have existed.

The following observations were made for index error:

November 11, 1865. Off the Arc.		November 12, 1865. Off the Arc.	
+0′ 40″	+1′ 50″	+1′ 50″	+1′ 20″
3 20	2 20	4 20	1 20
3 20	3 40	2 20	2 50
4 00	3 10	4 30	1 30
2 30	1 10	1 50	3 30
3 40	2 10	2 50	1 50
Mean, +2′ 39″		Mean, +2′ 30″	

And the probable error of one observation is three-quarters of a minute of arc.

Observations for error of chronometer have been made with the instrument, and it has been used to measure the difference of elevation of objects above and below the plane of the observer when it was impossible to get their reflection in the ordinary artificial horizon.

A thorough trial will be made of this improvement this season, when the results can be compared directly with the determinations of the Coast Survey.